TIER-SCALABLE RECONNAISSANCE© – A PARADIGM SHIFT IN AUTONOMOUS ROBOTIC PLANETARY EXPLORATION

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Robotic reconnaissance operations are called for in extreme environments such as space (including planetary atmospheres, surfaces, and subsurfaces), and hazardous or inaccessible areas on Earth. A fundamentally new planetary exploration mission concept, *Tier-Scalable Reconnaissance©*, originated by Wolfgang Fink at Caltech and his collaborators [1-10], replaces engineering and safety constrained mission designs that perform local ground-level reconnaissance with rovers and landers, or global mapping with an orbiter. The tier-scalable paradigm integrates multi-tier (orbit ⇔ atmosphere ⇔ surface/subsurface) and multi-agent (orbiter(s) ⇔ blimps ⇔ surface/subsurface agents or sensors) hierarchical mission architectures, and enables reconnaissance in real time (e.g., monitoring of transient events) on global, regional, and local scales for high science return and fully autonomous robotic missions, providing independence from human intervention, yet permitting manual override at any level. To support such tier-scalable reconnaissance missions, a high degree of operation autonomy is required, such as: (1) automatic mapping of an operational area from different vantage points; (2) automatic feature extraction and target/region-of-interest identification within the mapped operational area; (3) automatic target prioritization for follow-up examination; and (4) subsequent autonomous navigation and relocation of entire tiers or agents within tiers. The airborne and ground-tier agents can be inexpensive enough for the deployment of numerous, expendable agents that can address specific science-driven questions within the operational areas with a complementary suite of instruments. Tier-scalable reconnaissance would overcome the inherent challenge of geologic planetary surface exploration: Space/airborne agents possess overhead perspectives at different length scales and resolutions. They would map out areas of interest and acquire terrain data, processed through automated feature-extraction, feature data analysis, and science prioritization algorithms, to choose potential targets for in-situ examination by sensors or ground-agents and for determining safe passages to these targets. The sensors and ground-agents would gather in-situ data that complement the remote sensing data obtained by the space/airborne agents. Tier-scalable reconnaissance not only introduces mission redundancy and safety, but enables distributed, science-driven, and less constrained reconnaissance (both spatially and temporally) of prime locations on Mars, Titan, Venus, and elsewhere.

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